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Literacy Rates Analysis: An International Comparison

Macarena Arce

Literacy Rates Analysis: An International Comparison

by

Macarena Arce Vega

Advisor: Dr. Jingping Gu

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Sam M. Walton College of Business
University of Arkansas
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I. Introduction

When I was three years old I read a long word for the first time. The word was "mariposa" which means butterfly in Spanish. My mom was so proud that I was reading words with eight letters at a young age and that it was easy for me. At the time, I was living in Lima, Peru with all my family, and had a maid who took care of me named Bertha. Whenever my mom was at work I would try to practice how to read with books made for children and one day Bertha asked me if I could teach her what I was doing. It was exciting for me to show her something instead of the other way around, so I enjoyed trying to read words with Bertha every afternoon. My three-year-old self did not realize that Bertha, a mother of three, had never learned how to read. She had grown up in a rural area in Peru never had the privilege to attend any type of school and receive the education she deserved. She was a great person and very wise, but she could not read the name of the person she had voted for or the instructions to fill out her tax return. It took me a few years to realize that she only asked me to teach her because she did not want to admit in front of my parents that she could not read. And I always wondered what went wrong, and why some people were illiterate and some were not.

The United Nations (UN) defines literacy rates as the percentage of the population aged 15 years and over, who can both read and write with understanding a short simple statement on his/her everyday life. The UN Sustainable Development Goals (SDG) focuses one of its goals on education. SDG Goal 4: Ensure inclusive and quality education for all and promote lifelong learning, targets education in every country and is a way to fight low literacy rates around the world. Currently there are 781 million illiterate adults worldwide. Two thirds of those illiterate adults are female. The female illiteracy rates are particularly high in Sub-Saharan Africa. 95% of illiterate people live in developing countries (Verner, 2005). These facts are an example of the real need to invest on education.

The following research paper will be divided in two. The first part will present a literature review about the benefits of high literacy rates in social and economic terms, the costs of high literacy rates, and the challenges to improve literacy rates in developing countries. The second part of this paper will present a model to predict literacy rates by country and the methodology used.

II. Economics of Literacy Rates

A. Why are literacy rates so important?

Learning how to read is like getting glasses and seeing the world for the first time. Allowing someone to learn and become more knowledgeable increases that person's ability to think and to make effective decisions. By giving someone the chance to be literate this person can have more tools to have a better job and future. "Data show that adults who have attained higher levels of education are generally more likely than those with lower levels of educational attainment to report stronger civic engagement, in terms of voting, volunteering, political interest, and interpersonal trust" (OECD, 2013), which benefits society as well as the individual. More importantly, a literate population can help lower a country's poverty levels and increase community engagement. The best way to fight poverty is by generating income and creating a better quality of life for the population. Industrialization also happens easier if the population is educated and that can affect the developing country's GDP and economy in general.

The UN also defines the adult literacy rate as "the proportion of the adult population aged 15 years and over that is literate, expressed as a rate (%)." Literacy is closely linked to indicators reflecting basic needs such as education, health, standard of living, capacity building, and communication. Literacy is also critical for promoting sustainable development and improving the lives of the population. Literacy is also achieved through educational programs, so having a more educated goes hand in hand with high literacy rates.

B. Social Benefits of High Literacy Rates

There are numerous social benefits that can be achieved through high literacy rates. First, civic benefits will increase when the literacy rate increases. The ability for individuals to make informed decisions can help them at the time when they vote or when they participate in community activities. Second, crime rates decrease when the population is more educated. A study made in the University of Maryland showed that "As education expenditure increase (as a proportion of total expenditures) the violent and property crime rate decrease" (Guerra, 2012). Third, a literate population provides social capital. Literate people tend to have more citizenship values and participate in more volunteer activities. They are more likely to trust other people and have higher racial tolerance (Murray, 2009). Fourth, education helps families achieve a better use of their resources and have a future oriented vision. Parenting is always a challenge and couples with more information can prepare and forecast problems they may encounter. Literate individuals also tend to be happier because their educated decisions give them greater satisfaction. This also helps them improve their quality of life and provide new interests and opportunities to spend their resources (Post, 2016). An example could be using their income to travel or to invest their earnings in a profitable business. Moreover, the health of the population can be improved if they are educated on how to prevent and treat illnesses and this can be achieved by allowing them to have access to this information by reading it. An example could be eating habits and different health resources provided by the government. In developing countries another social benefit is the social gap that can be decreased through education. Since not every child has the same access to education these children grow up unaware of how to react in different situations and without knowing what decisions could be more beneficial for themselves and their society.

C. Economic Benefits of High Literacy Rates

A literate population can create several economic benefits in different ways. First, income increases when there is more education, "Earnings increase with each level of education" (OECD, 2010). This may be the biggest incentive for countries in development to invest in education and to fight illiteracy. With a higher level of literacy, the population can obtain better jobs, increase their salaries, spend and consume more, pay more taxes to the government, and continue increasing the country's GDP. Second, studies by the OECD show that individuals who continue their education have higher incomes and can contribute more to society. Literacy can be seen as an investment in society in terms of GDP but also to individuals in terms of wages, employment and income. With higher levels of education people can obtain better jobs and increase opportunities for business, later leading to increasing industrialization and the level of employment. Furthermore, developing countries can benefit immensely from a more capacitated population, since they would have a larger amount of human capital that could provide higher earning labor. With higher wages also comes an increase in the taxes that the government would receive and therefore there would be more resources for the government to invest on the country. People can also have more discretionary income that they could allocate to charitable donations and further contribute to society. Overall high literacy rates create positive economic outcomes by increasing the employability of the population and its chances to have a greater economic development.

D. Economic Costs of High Literacy Rates

Governments around the world choose how they want to spend their resources and how they can benefit society allocating them. However, there are diverse costs that go along providing education in a country. First, the operating costs to provide education are extensive and a great barrier for countries in development. Building schools, roads, and hiring teachers is something that these countries need to invest on to be able to educate their population. However, the expenditure they have to make inquires a large amount of money. Developing countries face the choice of short-term and long-term investments in education. This trade-off brings up the opportunity costs of education as well. A country can choose to spend less in education to use that money to build infrastructure. Governments evaluate what is the most urgent need and try to fulfill it immediately forgetting to use a long-term educational plan because the other need is more pertinent. This causes an inefficiency because it does not allow the population to have a greater development, but at the same time they have a current need they have to satisfy immediately. Another cost that countries have to incur is their need for updated technologies to provide quality education. Having a quality education can help decrease the gap between developed and developing countries. Part of increasing literacy rates is also having good teachers, which is a large economic cost because the country has to pay decent salaries to retain good faculty.

E. Why high literacy rates are still a challenge in developing countries?

Even though the economic costs of education are similar between developed and developing countries, there are several challenges that are particularly related to developing countries. First, developing countries not always count with the resources to afford a quality

education for their whole population. This brings up again the trade-off on how to invest the government resources to benefit society. Many non-profits provide aid in developing countries to help children in need obtain a better-quality education because the one provided by the government may not be optimal. Second, infrastructure is necessary but it is not always available. Children from rural areas may lack access to schools and that creates a huge inefficiency (Villalobos, 2013). Since these children cannot attend their classes from an early age, then they do not enroll or attend school at all. Third, malnutrition in developing countries is a huge factor determining if students are going to succeed in school or not. The children may be seen as less intelligent or less capable to solve simple problems, but the cause of that can be the lack of nutrients in their daily diet. "Children from developing countries with chronic undernutrition have associated increased anxiety, attention deficits, increased school absence and tardiness, lower levels of social responsiveness, and decreased affect" (Holden, 2008) and all of these factors influence their success in school. Fourth, many students end up repeating first grade and this constant repetition of grades ends up in students dropping out of school. Villalobos used Paraguay as an example where students from lower income families living in rural areas are most likely going to repeat first grade and later on dropping out of school; despite the high amounts of GDP that the country spends on education. Fifth, another challenge for education in developing countries is that many of them have a centralized economy and the aid or development programs do not reach all of their rural areas. This is also related to the lack of infrastructure in rural areas, where students need to travel long distances to school and may still not receive the best education. This challenge may need a long-term solution but at the same time it is a vicious cycle that can continue if education does not improve in those areas. Sixth, many children in developing countries enter the workforce before finishing their studies and this creates another inefficiency because these children are not obtaining the education they deserve and need and also they are working when they should not be under that pressure. "Youth who previously were child laborers became more likely to work in unpaid family jobs" (Mansur, 2016). Moreover, another issue that countries in development face is corruption. This can put a huge break on economic development because the allocated resources for education end up in the wrong hands and do not reach the children who most need it. Furthermore, teachers can create another inefficiency when they do not show up to teach classes. An example can be the strikes that happened around August in several South American countries like Argentina, Chile, Colombia, Peru and Paraguay. In Peru the strike lasted more than a months and students did not have classes during that period of time.

F. What aids exist to improve literacy rates?

There are several non-profits that provide different types of aid to developing countries to improve their quality of education. As mentioned before, education is part of the SDGs and it is a priority for global organizations like the UN, the World Bank, the International Monetary Fund, and many others. There are numerous sub-groups that provide services or research to different countries like UNICEF, ECOSOC, UNDP, etc. These organizations try to reach agreements and develop plans to help countries achieve their SDGs. Moreover, there are smaller organizations that focus in smaller areas and provide short-term solutions.

III. Data

The data utilized was in the regression was retrieved from The World Bank, The World Factbook from the Central Intelligence agency and from UN Data. All the data used in this model is from the year 2011 since it had the largest number of literacy rates reported in the past ten years. 77 countries were analyzed.

G. Countries used in the Regression

1. Albania
2. Angola
3. Antigua and Barbuda
4. Argentina
5. Armenia
6. Bangladesh
7. Bosnia and Herzegovina
8. Botswana
9. Brunei Darussalam
10. Bulgaria
11. Cabo Verde
12. Central African Republic
13. Chad
14. Colombia
15. Comoros
16. Costa Rica
17. Cote d'Ivoire
18. Croatia
19. Cuba
20. Cyprus
21. Dominican Republic
22. Ecuador
23. Equatorial Guinea
24. Eritrea
25. Estonia
26. Gabon
27. Gambia, The
28. Georgia
29. Greece
30. Guatemala
31. Guinea-Bissau
32. Honduras
33. Hungary
34. Indonesia
35. Iraq
36. Italy
37. Jamaica
38. Jordan
39. Latvia

40. Libya
41. Lithuania
42. Mali
43. Mauritania
44. Mauritius
45. Mexico
46. Mongolia
47. Montenegro
48. Morocco
49. Myanmar
50. Nepal
51. Papua New Guinea
52. Peru
53. Poland
54. Portugal
55. Moldova
56. Romania
57. Samoa
58. Saudi Arabia
59. Serbia
60. Seychelles
61. Sierra Leone
62. Slovenia
63. South Africa
64. Swaziland
65. Syrian Arab Republic
66. Tajikistan
67. Macedonia, FYR
68. Togo
69. Trinidad and Tobago
70. Turkey
71. Turkmenistan
72. Ukraine
73. Uzbekistan
74. Vanuatu
75. Vietnam
76. Yemen, Rep.
77. Zimbabwe


Literacy Rates in 2011
Literacy Rate
99.8
33.4
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IV. Models and Methodology

H. Model A

Regression analysis will be used to analyze factors that contribute to international literacy rates.

Dependent Variable: Adult Literacy Rate % in country i

Independent Variables:

- Primary School Enrollment (%): both female and male students
- Life Expectancy (years)
- GDP Per Capita
- Fertility Rate
- Undernourishment %
- Student-Teacher Ratio
- Primary School Completion
- Electricity (% of population)
- Democracy* Government Expenditure

1. Assumptions

Positive Relationships

- Primary School Enrollment (%): As primary school enrollment increases, literacy rates increase. The population receiving an education is more likely to learn how to read.
- Life Expectancy (years): As life expectancy increases, literacy rates increase. A higher life expectancy is expected from people who are more knowledgeable of how to take care of their life.
- GDP Per Capita: As GDP per capita increases, literacy rates increase. A higher level of education can obtain a higher income.
- Primary School Completion: As primary school completion increases, literacy rates increase. Children completing primary school should know how to read by the time they finish their program.
- Electricity (% of population): As electricity increases, literacy rates increase. This is a measure of quality of life, and households with electricity are more likely to afford sending their children to school. On the other side, households without electricity may have parents with lower level of education and higher chances that they are illiterate.
- Democracy*Government Expenditure: Democracy times Government expenditure on education, total (% of GDP), where Democracy is a binary variable
    - 1 = the country is a democracy,
    - 0 = the country is not a democracy

  This is an interaction variable, as government expenditure increases, literacy rates increase. Greater government expenditure can contribute to more schools and learning material.

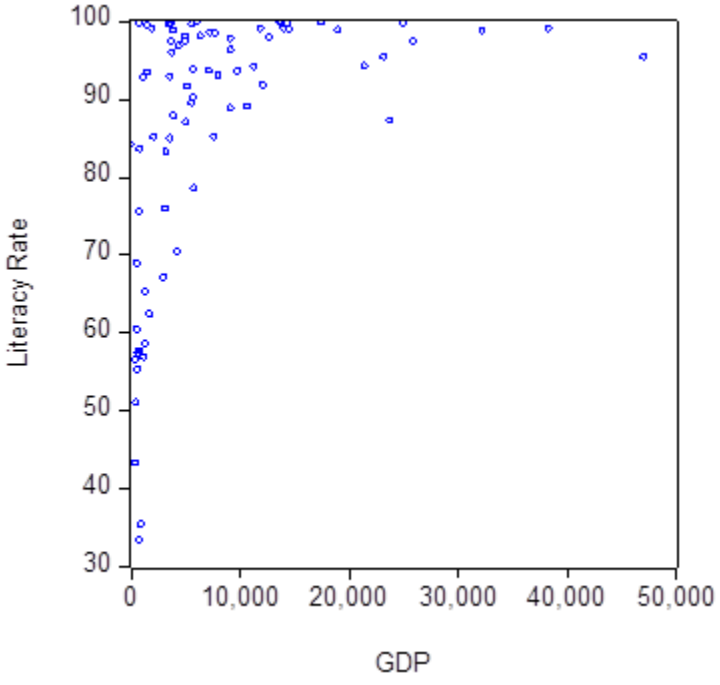
Negative Relationships

- Fertility Rate: As fertility rates increase, literacy rates decrease. Higher fertility rates normally represent lower levels of education.
- Undernourishment %: Prevalence of undernourishment (% of population). As undernourishment increases, literacy rates decrease. An undernourished person has less ability to learn than someone with proper alimentation.
- Student-Teacher Ratio: As student-teacher ratio increases, literacy rates decrease. When there are too many students in a classroom, the teachers cannot spend more time with individual students, leading to inefficiencies in the classroom.

2. Correlation

	LIT RATE	*PSE*	*LEXPECT*	*GDP*	*FERTR*	*UNDERN*	*STR*	*PRIMCOM*	*ELEC*	*DEM*GOVEDU*
LIT RATE	1									
PSE	0.32752183	1								
LEXPECT	0.71973638	0.4492983	1							
GDP	0.44204745	0.18406278	0.48202126	1						
FERTR	-0.7976824	-0.3413902	-0.8237728	-0.4313447	1					
UNDERN	-0.433862	-0.1410774	-0.564129	-0.3791777	0.47683296	1				
STR	-0.6316492	0.06548178	-0.5759753	-0.285425	0.55128385	0.40377382	1			
PRIMCOM	0.274347	0.62131543	0.41152854	0.26479661	-0.3003819	-0.1700244	0.02851387	1		
ELEC	0.83980317	0.39636536	0.83146922	0.42310558	-0.800944	-0.5058334	-0.5094358	0.39533547	1	
DEM*GOVEDU	0.39955013	0.35402469	0.38869254	0.34455614	-0.4953409	-0.2844993	-0.041014	0.26163302	0.38826745	1

The correlation results matched the assumptions of how literacy rates is correlated with the independent variables. Here is a graph where it is easy to appreciate the positive relationship between GDP and literacy rates.



3. Descriptive Statistics

	LITERACY_RATE	*ENROLLMENT*	*LIFE_EXPECTANCY*	*GDP*	*FERTILITY_RATE*
Mean	86.07532468	60.79376493	69.56858853	7986.931775	2.827701299
Standard Error	1.946510589	4.981339684	0.942645015	1032.363231	0.16124084
Median	93.5	88.5205307	72.57278049	5064.041106	2.404
Standard Deviation	17.0805611	43.71107833	8.271676435	9058.950588	1.414882625
Sample Variance	291.7455673	1910.658368	68.42063104	82064585.76	2.001892844
Kurtosis	1.148393201	-1.541614169	0.127864522	5.213994347	-0.129117674
Skewness	-1.439017223	-0.617352244	-0.99223206	2.120059531	0.940176025
Range	66.4	99.32473755	33.93082927	47017.0273	5.252
Minimum	33.4	0	48.25697561	0	1.23
Maximum	99.8	99.32473755	82.18780488	47017.0273	6.482
Sum	6627.8	4681.1199	5356.781317	614993.7467	217.733
Count	77	77	77	77	77

	%UNDERNOUR	*STUDENT_TEACHER*	*PRIMARY_COM*	*ELECTRICITY*	*DEM*GOVEDU*
Mean	9.842857143	17.60118893	61.71670909	80.89895901	1.632034937
Standard Error	1.092491976	1.873114885	5.120860654	3.208559953	0.275311725
Median	6.1	15.62440014	86.68910217	98	0
Standard Deviation	9.58657818	16.43651641	44.93536987	28.15499932	2.415850583
Sample Variance	91.9024812	270.1590717	2019.187465	792.7039867	5.836334041
Kurtosis	1.155809064	2.048898856	-1.555164824	0.515055985	-0.456862713
Skewness	1.352154492	1.130863417	-0.488592307	-1.360390932	1.02050613
Range	38.9	81.31050873	119.9341583	93.16213942	8.559700012
Minimum	0	0	0	6.837860584	0
Maximum	38.9	81.31050873	119.9341583	100	8.559700012
Sum	757.9	1355.291548	4752.1866	6229.219844	125.6666901
Count	77	77	77	77	77

4. Regression – Model A

Dependent Variable: Literacy Rates

Independent Variables:

- PSE: primary school enrollment (%)
- Lexpect: life expectancy (years)
- GDP: GDP per capita
- Fertr: Fertility rate
- Undern: Undernourishment %
- GovExp: Government Expenditure on education, total (% of government expenditure)
- STR: Student-Teacher ratio
- PrimCom: Primary Completion
- Elec: Electricity

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.90430179
R Square	0.817761727
Adjusted R Square	0.793281958
Standard Error	7.765891597
Observations	77

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	9	18131.95527	2014.6617	33.4056158	2.02183E-21
Residual	67	4040.707844	60.3090723		
Total	76	22172.66312			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	114.0172874	18.88824832	6.03641404	7.6669E-08
PSE	0.053768989	0.029145409	1.84485277	0.06947939
LEXPECT	-0.676959359	0.256277301	-2.6415112	0.01026272
GDP	0.000169239	0.000116776	1.44926193	0.15192908
FERTR	-3.597191333	1.308458499	-2.7491826	0.00767186
UNDERN	0.067048091	0.116495123	0.57554419	0.56685138
STR	-0.350245043	0.078552072	-4.4587627	3.2209E-05
PRIMCOM	-0.013135189	0.026559215	-0.4945624	0.62252687
ELEC	0.373981656	0.062250741	6.00766597	8.6029E-08
DEM*GOVEDU	0.468817832	0.465278363	1.00760721	0.31726826

5. Equation

$$Literacy\ Rate = 114.0173 + 0.0537\ PSE - 0.677\ Lexpect + 0.0002\ GDPpC - 3.5972\ Fertr + 0.0670\ Undern - 0.3502\ STR - 0.0131\ PrimCom + 0.374\ Elec + 0.4688\ Dem * GovExp$$

The independent variables explain 81.78% of the variation of literacy rates around the world. The most significant independent variables are life expectancy, fertility rate, student-teacher ratio, and electricity. Some unexpected outcomes are that life expectancy and primary completion have negative relationships and undernourishment had a positive relationship. However, undernourishment and primary completion do not have significant p-values. The correlations between literacy rates with undernourishment and life expectancy did match the assumptions.

6. Actual vs. Predicted Value and Residuals

Using the equation for Model A:

$$Literacy\ Rate = 114.0173 + 0.0537\ PSE - 0.677\ Lexpect + 0.0002\ GDPpC - 3.5972\ Fertr + 0.0670\ Undern - 0.3502\ STR - 0.0131\ PrimCom + 0.374\ Elec + 0.4688\ Dem * GovExp$$

We can see if the prediction is close to the actual literacy rate for the year 2011. We can also calculate the residual by subtracting the actual value minus the prediction value. These five countries show the actual and predicted literacy rates. Something interesting is that some countries like Latvia had predictions bigger than 100, which is not possible in real life.

Country	2011 Literacy Rate	Prediction	Residual
Brunei Darussalam	95.4	95.49665776	-0.09665776
Latvia	99.8	101.5772431	-1.777243128
Dominican Republic	90.1	88.61321638	1.48678362
Botswana	85.1	85.29896594	-0.198965936
Chad	35.4	42.65626375	-7.256263753

For Brunei Darussalam and Botswana, the model worked really well and the residual was very small. For Dominican Republic and Latvia the model was still close to the actual result. Chad had a bigger difference since the actual literacy rate value was smaller than predicted. Some of the results had bigger residuals because an independent variable value was missing as well.

I. Model B

This model will use different factors that affect literacy rates that were not present in Model A. The independent variables in Model B are more policy relates.

Dependent Variable: Adult Literacy Rate % in country i

Independent Variables:

- GDP: Gross Domestic Product per Capita
- GovEdu: Government expenditure on education, total (% of GDP)
- RFAID: Financial Aid, official development assistance and official aid received (% of GDP)
- RFDI: Foreign Direct Investment (% of GDP)
- Trade: Openness Index (% of GDP)
- Dev: Developing Countries
- Dem* GovEdu: Democracy*Government expenditure on education, total (% of GDP)
- STR: Student-teacher ratio

1. Assumptions

Positive Relationships

- GDP per Capita: As GDP per capita increases, literacy rates increase. A higher level of education can obtain a higher income.
  GovEdu: Greater government expenditure can contribute to more schools and learning material.
- RFAID: Countries that receive more aid will be able to increase their literacy rates
- RFDI: Countries with higher foreign direct investments will have more industries, which will lead to more jobs and help have a more educated population
- Trade: openness to trade demonstrates that the country is more educated in terms of exchanging resources between countries.
- Dem* GovEdu: Interaction variable of Democracy times Government Expenditure on education, as a percentage of GDP, where Democracy is a binary variable
  - 1 = the country is a democracy,
  - 0 = the country is not a democracy

  As government expenditure increases, literacy rates increase. Greater government expenditure can contribute to more schools and learning material. Democratic countries are more likely to implement this money more efficiently than non-democratic ones.

Negative Relationships

- Developing Countries: Defined as developing countries by the United Nations World Economic Situation and Prospects (WESP) in 2014. These countries are

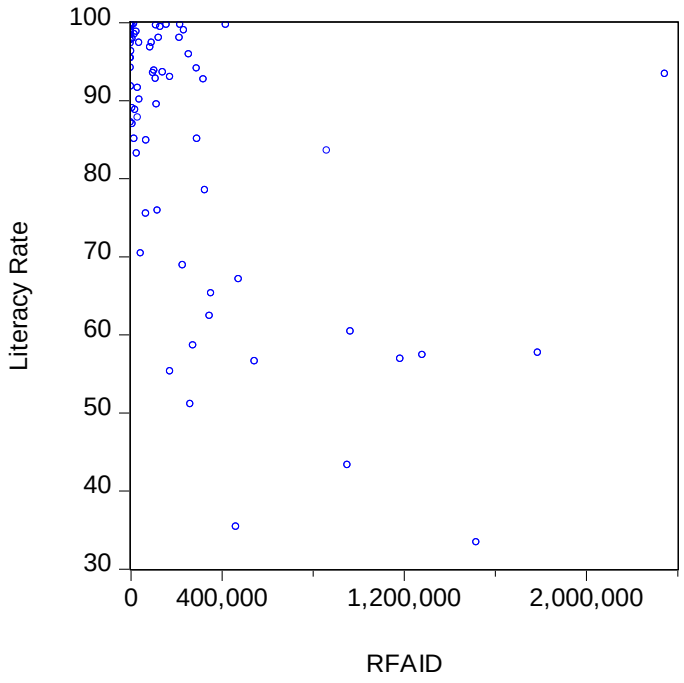
more likely to have lower literacy rates, so the relationship will show that by being a developing country the literacy rates will be smaller.

- Student-Teacher Ratio: As student-teacher ratio increases, literacy rates decrease. When there are too many students in a classroom, the teachers cannot spend more time with individual students, leading to inefficiencies in the classroom.

2. Correlation

	LIT_RATE	*GDP*	*GDP^2*	*GOVEDU*	*RFAID*	*RFDI*	*TRADE*	*DEV*	*DEM*GOVEDU*	*STR*
LITERACY_RATE	1									
GDP	0.44302892	1								
GDP^2	0.25866331	0.92648451	1							
GOVEDU	0.11469637	0.15441248	0.12939221	1						
RFAID	-0.5543124	-0.3909185	-0.2316584	0.03336018	1					
RFDI	0.04592917	-0.1484535	-0.1188818	0.14889914	0.40381062	1				
TRADE	0.27555713	0.21642766	0.10979033	0.26152483	-0.0846739	-0.0930149	1			
DEV	-0.4725419	-0.3542247	-0.2363314	-0.1843895	0.27226959	0.09207926	-0.2502583	1		
DEM*GOVEDU	0.39976207	0.33940787	0.18333299	0.71821207	-0.3036719	0.05556994	0.25711631	-0.2982801	1	
STR	-0.6382539	-0.3018839	-0.1965863	0.240544	0.38366221	0.03949595	-0.0917989	0.27753857	-0.0512056	1

An unexpected result was shown in the correlation and is that RFAID and literacy rates had a negative relationship. This could mean that foreign aid is more likely to go to poor countries with low literacy rates. All the other assumptions matched the correlation results.



3. Descriptive Statistics

	LITERACY_RATE	*GDP*	*GOVEDU*	*RFAID*
Mean	86.07532468	7986.931775	2.666375196	241874.0849
Standard Error	1.946510589	1032.363231	0.270290651	49450.88761
Median	93.5	5064.041106	3.028270006	85522.82422
Standard Deviation	17.0805611	9058.950588	2.371790838	433929.7777
Sample Variance	291.7455673	82064585.76	5.625391777	1.88295E+11
Kurtosis	1.148393201	5.213994347	-1.183218701	9.219745615
Skewness	-1.439017223	2.120059531	0.175477497	2.908439697
Range	66.4	47017.0273	8.559700012	2346113.541
Minimum	33.4	0	0	0
Maximum	99.8	47017.0273	8.559700012	2346113.541
Sum	6627.8	614993.7467	205.3108901	18624304.54
Count	77	77	77	77

	RFDI	*TRADE*	*DEV*	*STR*
Mean	554758.173	84.64383034	0.714285714	17.60118893
Standard Error	112883.1778	4.420005671	0.051819732	1.873114885
Median	193064.4666	83.42680017	1	15.62440014
Standard Deviation	990545.8655	38.78539236	0.454716304	16.43651641
Sample Variance	9.81181E+11	1504.30666	0.206766917	270.1590717
Kurtosis	12.43934313	0.962204281	-1.092756757	2.048898856
Skewness	3.144364683	0.268970408	-0.967636295	1.130863417
Range	6361969.381	207.1570635	1	81.31050873
Minimum	-703364.015	0	0	0
Maximum	5658605.366	207.1570635	1	81.31050873
Sum	42716379.32	6517.574936	55	1355.291548
Count	77	77	77	77

4. Regression – Model B

Dependent Variable:

- Literacy Rate: adult literacy rate % in country i

Independent Variables:

- GDP: Gross Domestic Product per Capita
- GOVEDU: Government expenditure on education, total (% of GDP)
- RFAID: Financial Aid, official development assistance and official aid received (% of GDP)
- RFDI: Foreign Direct Investment (% of GDP)
- TRADE: Openness Index (% of GDP)
- DEV: Developing Countries
- DEM*GOVEDU: Democracy*Government expenditure on education, total (% of GDP)
- STR: Student-teacher ratio

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.834699972
R Square	0.696724043
Adjusted R Square	0.65536823
Standard Error	10.09292935
Observations	76

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	9	15445.47316	1716.16368	16.8470646	5.24604E-14
Residual	66	6723.236707	101.867223		
Total	75	22168.70987			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	89.31247874	4.753523528	18.7886897	3.4509E-28
GDP	0.00075932	0.000472014	1.60868241	0.11245927
GDP^2	-1.58661E-08	1.13284E-08	-1.4005638	0.16602855
GOVEDU	0.52455665	0.849200432	0.61770653	0.53889439
RFAID	-1.31709E-05	3.68275E-06	-3.5763634	0.00065808
RFDI	3.97213E-06	1.34495E-06	2.95335944	0.00435143
TRADE	0.047036007	0.034342316	1.36962246	0.1754469
DEV	-6.096707	2.931673552	-2.0795996	0.0414506
DEM*GOVEDU	0.418917561	0.880490178	0.47577767	0.63580385
STR	-0.439900735	0.086101691	-5.1090836	2.9742E-06

The regression has 76 observations instead of 77 because Syrian Arab Republic only had one out of the 9 variables used in this model so it was removed. The Large F and small Significance F show that the model is significant.

5. Equation

$$Literacy\ Rate = 89.3125 + 0.0008\ GDP - 1.59\text{E-}08\ GDP^2 + 0.5246\ GOVEDU - 1.32\text{E-}05\ RFAID + 3.97\text{E-}06\ RFDI + 0.047\ TRADE - 6.0967\ DEV + 0.4189\ DEM * GOVEDU - 0.4399\ STR$$

The independent variables explain 69.67% of the variation of literacy rates around the world. The most significant independent variables are foreign aid, foreign direct investments, developing countries and student-teacher ratio. An unexpected outcome is the negative relationship with foreign aid, as mentioned before. All the other independent variables relationships did match the assumptions but are not necessarily significant.

6. Actual vs. Predicted Value and Residual

Using the equation for Model B, we can see if the prediction is close to the actual literacy rate for the year 2011. We can also calculate the residual by subtracting the actual value minus the prediction value. These five countries show the actual and predicted literacy rates. Something interesting is that some countries like Cyprus had predictions bigger than 100, which is not possible in real life.

Country	2011 Literacy Rate	Prediction	Residual
Mexico	93.5	93.07022282	0.429777185
Cyprus	98.7	101.2296067	-2.529606694
Costa Rica	96.3	91.70934859	4.590651413
Nepal	57.4	58.36142313	-0.961423134
Chad	35.4	56.43484754	-21.03484754

For Mexico and Nepal, the model worked really well and the residual was very small. For Costa Rica and Cyprus the model was still close to the actual result. Chad had a bigger difference since the actual literacy rate value was smaller than predicted. Some of the results had bigger residuals because an independent variable value was missing as well.

J. Developing Countries

Model B was filtered to just analyze developing countries and create a new equation. These countries were defined as developing countries by the United Nations World Economic Situation and Prospects (WESP) in 2014. A total of 55 countries were used in the regression.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.831534837
R Square	0.691450186
Adjusted R Square	0.637789348
Standard Error	10.74107912
Observations	55

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	8	11892.94118	1486.61765	12.8855646	1.63359E-09
Residual	46	5307.055909	115.370781		
Total	54	17199.99709			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	79.14921069	4.248992979	18.6277575	4.641E-23
GDP	0.001464883	0.000569313	2.57307139	0.01337046
GDP^2	-2.55627E-08	1.32912E-08	-1.9232801	0.06064735
GOVEDU	0.433551595	1.038944321	0.41730012	0.67840016
RFAID	-9.66022E-06	4.22991E-06	-2.283787	0.02704908
RFDI	3.3714E-06	1.53474E-06	2.19672589	0.03311707
TRADE	0.03959958	0.04075637	0.97161695	0.33632271
DEM*GOVEDU	1.248600468	1.092887766	1.14247822	0.25916712
STR	-0.445527954	0.093692739	-4.7552025	1.989E-05

1. Equation for Developing Countries:

$$Literacy\ Rate = 791492 + 0.0015\ GDP - 2.56\text{E-}08\ GDP^2 + 0.4336\ GOVEDU - 9.66\text{E-}06\ RFAID + 3.37\text{E-}06\ RFDI + 0.0396\ TRADE + 1.2486\ DEM * GOVEDU - 0.4455\ STR$$

We can see that the equation for developing countries compared to the equation for all countries, including developed countries and economies in transition, shows that the intercept decreases. The coefficients for GDP, the interaction variable between democracy and government expenditure, and student-teacher increase. Despite not being significant at a p-value level, the interaction variable is more significant in countries in developing than for all countries.

V. Conclusions

Model A

- 79% of variation of literacy rates around the world be can explained by life expectancy, fertility rate, student-teacher ratio, and electricity.
- Primary school enrollment (%), GDP per capita, electricity and democracy*government expenditure, all have positive correlations to the country's literacy rates. These match the assumptions made prior doing the regression.
- Life expectancy (years), fertility rate, student-teacher ratio and primary completion, all have negative correlations to the country's literacy rates.
- Undernourishment was expected to be negative but it ended up having a positive relationship. However, it does not have a significant p-value.
- Life expectancy in years did not have a positive relationship. This could be due to the fact that older generations never received the necessary education and are aging without learning how to read but receive care from educated younger people. It could also be due to migration.
- Primary completion also had a negative relationship. This could mean that the education they are receiving may not be as beneficial or effective as it should be. Maybe too many students are in the same classroom and even though they finish primary education they may have not learned how to read completely.
- The actual vs. predicted examples showcased different results from the model. The residuals also presented a normal standard deviation shape.

Model B

- 65% of variation of literacy rates around the world be can explained by GDP, government spending on education, foreign aid, openness index and student teacher ratio.
- GDP is one of the most important factors for literacy rates. It affects literacy rates nonlinearly.
- Government expenditure in education, foreign direct investments, openness to trade, and Dem*GovEdu have positive relationships with literacy rates. This means that an increase in any of those variables will increase literacy rates.
- Developing countries, and student-teacher ratio have negative relationships with literacy rates.
- The negative coefficient in front of RFAID probably means foreign aid is more likely to go to poor countries with low literacy rate.
- The model shows that Developing countries generally have 6% lower literacy rates.
- Globalization, through foreign direct investment and trade, may help to improve the literacy rates.
- Keeping the student-teacher ratio low helps students learn better and increases literacy rates.
- Model B could have improved if the data for the independent variables had been from the previous year, in this case 2010, to predict literacy rates for 2011.

Comparison of Model A and Model B

- Model A had a higher R^2 than Model B. This means that Model A can explain better the variation of literacy rates.
- The Significance F in Model A was smaller than the Significance F in Model B. This means that Model A can predict better literacy rates around the world.
- The residuals for Model A were also smaller than the ones for Model B.
- Model B is more policy related than Model A. Using Model B it is easier to analyze how to improve literacy rates. The variables used in Model B like RFDI and Trade can be improved by policy makers inside the country.
- Despite Model A being more significant than Model B, they both are valid and can be used in different circumstances. Model A can be used to predict current literacy rates, and Model B could be used to improve literacy rates.

Developing Countries

- Developing countries were analyzed in a separate regression based on Model B.
- The adjusted R^2 decreased from .66 to .64 from Model B to Developing Countries. This means that the variable developing countries had significance in Model B.
- The intercept decreased from 89.31 to 79.15, showing that the starting point for developing countries is smaller.
- This model presented significant relationships with GDP, foreign aid, foreign direct investment, and student-teacher ratio.
- GDP is more significant in developing countries than in all countries.
- Government expenditure in education also showed higher importance in developing countries.
- Foreign aid is still negative in developing countries, but its p-value is bigger than for all countries.
- The significance increased for the interaction variable of democracy and government expenditure.

VI. References

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